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Subject: Dwarf Mistletoe Infestation in the McCracken Project Area

To: District Ranger, Williams RD, Kaibab NF

At the request of Mark Herron, District Silviculturist, I am providing an assessment of the dwarf mistletoe (DM) infestation in the McCracken Project Area. The primary objectives of the 17,337 acre project are to improve ecosystem health and resiliency by reducing forest fuels, increase the diversity of vegetative species and structure, and improve quality of wildlife habitat. Silvicultural prescriptions are aimed at promoting the development of multiple age classes of trees by applying uneven-aged silviculture treatments in ponderosa pine forest types. There is a high incidence of dwarf mistletoe infection in the analysis area. Since the incidence of DM infection within a stand greatly influences the growth and development of trees overtime, the prevalence of DM is considered when selecting sites for even- or uneven-aged management. This report includes; a summary of the District's stand exam survey data on DM incidence in the project area, a discussion of the influence of DM on stand development, and recommendations to minimize impacts of DM infection in developing stands.

McCracken Project

The McCracken project area is dominated by ponderosa pine forest cover types (12,559 acres) composed of ponderosa pine and a mix of Gambel oak and juniper. Other forest cover types in the project area include juniper, pinyon-juniper, and oak woodlands. Natural disturbances and historic processes have been altered for more than 100 years across the Kaibab NF and much of the project area is at increased risk of unnaturally intense wildland fire behavior and poor tree health due to competition of densely stocked trees for limited resources, dwarf mistletoe infection, and increased risk of bark beetle outbreaks.

The incidence and intensity of southwestern dwarf mistletoe infection in ponderosa pine in the McCracken project area was quantified from stand exam data. Dwarf mistletoe infection incidence is simply the percent of host trees infected within a site. This is then summarized across the project area (Table 1) and includes the percent of ponderosa pine sites infected across the project area. In general, 58% of ponderosa pine sites are infected and the majority of these have more than 25% of host type trees infected. In the more severely infected stands, deformed and stunted trees are common and mortality is evident. Information on the percentage of host trees infected with DM is useful in developing silvicultural prescriptions and is discussed below.

Table 1. Incidence of dwarf mistletoe infected ponderosa pine trees within the McCracken Project Area.		
Percent Trees Infected	**# of Stands**	**Percent of Stands**
None	102	41%
<15%	14	6%
Less than 25%	29	12%
Greater than 25%	101	41%

The intensity of DM infection is estimated by assigning each inventory tree a dwarf mistletoe rating (DMR) using Hawksworth's[i] 6-class system. This rating system divides the live crown of trees into thirds, and each third is rated separately as: 0, no mistletoe infection; 1, less than 50% of live branches infected; 2, more than 50% of live branches infected. The ratings for each third are totaled to obtain a DMR for a tree ranging from 0-6. On average, it takes ten years for infection to progress 1 DMR class (e.g. from a DMR class 3 to class 4). Dwarf mistletoe ratings have been linked to growth and mortality impacts.

Table 2. Intensity of dwarf mistletoe infection in the McCracken Project Area.

DMR	**Infection Level**	**Number of Sitess in the McCracken Project Area**
0	None	102
0.1 - 0.5	Low	54
0.6 - 1.0	Moderate	41
1.1 - 2.0	High	32
>2.0	Severe	17

The mean DMR for a site (stand) is computed by adding the DMRs for all live trees, infected and uninfected, greater than 1 inch diameter at breast height (DBH) in the stand and dividing by the total number of trees. The mean site DMR is generalized into low, moderate, high, and severe infection level categories as a way of describing the intensity of infection across the McCracken project area (Table 2). As would be expected of a disease with a slow rate of spread, there are more stands with low and moderate levels of DM infection than sites with high and severe levels of infection.

Dwarf Mistletoe Biology and Impacts

Dwarf mistletoes are parasitic, seed-bearing plants that depend on their hosts almost completely for water and nutrients. They cause significant changes in physiological processes and structural characteristics of infected trees, which result in changes in the structure and function of forest communities[ii] [iii]. Infected host trees experience growth loss, mortality, and reduced seed production and viability. Overall effects on forest structure in a site that has been infected for many generations include: increased stand openings; lower crown canopy; denser canopy due to witches' brooms; and fewer large diameter trees.

Growth loss does not begin to show until infection is above DMR class 3. Generally, 10-year periodic diameter increment reduction is 10% for class 4 trees, 30% for class 5 trees, and 50% or more for class 6 trees[iv]. Ten-year mortality rates as a percent of trees dying per decade due to dwarf mistletoe infection is greatest in DMR class 5 and 6 trees, at 23% and 34%, respectively. Infected trees are often predisposed to bark beetle attack. During a 2002-2003 bark beetle outbreak on the Williams RD, ponderosa pine mortality within dwarf mistletoe-infested stands was found to be greatest in severely infected trees[v].

The direct and indirect effects of dwarf mistletoe infection on its host can provide forage and nesting habitat for many species of birds[vi] and mammals[vii]. Few birds are known to eat dwarf mistletoe directly, but insectivorous birds feed on insects that feed on the mistletoe and on bark beetles that attack weakened infected trees. Recent research between mistletoe related variables (e.g., the amount of mistletoe on a site and snag density) and bird species abundance in ponderosa pine sites in northern Arizona[viii] observed mixed results. A positive relationship was found for some species, a negative correlation for others, and no correlation for approximately one-third of the species studied. Three of the 4 species that were positively correlated with dwarf mistletoe infestation or snag density were cavity-nesting birds. The only foliage nesting bird with a positive relationship was western tanager. Although Bennetts et al.[ix] found a positive correlation between mistletoe infection and 24 bird species, the sites were in mixed-conifer forests in Colorado that had an understory shrub component absent from the study sites in Arizona.

Fire history is one of the primary ecological factors in determining the distribution and intensity of dwarf mistletoes in coniferous forests. Relatively complete burns may have a sanitizing effect on infected stands; while partial burns can lead to rapid infection of regeneration if scattered infected trees remain overtop newly established regeneration. Fire, both prescribed and natural, can have a sanitizing effect, in which heavily infected trees and the lower branches of moderately and lightly infected trees are killed by fire, thereby lowering infection levels.

Based on present understanding of mistletoe ecology, increases in host abundance over the past 150 years, and decreases in fire frequency; it can be inferred that dwarf mistletoe abundance was likely lower in the historic period[x]. A four percent increase in the incidence of southwestern dwarf mistletoe infection was observed in a 25 year period on the Kaibab NF, based on comparisons of road side surveys conducted in the 1950s and 1980s[xi] [xii].

Treatment Options

The focus of managing mistletoe is to reduce the impacts of mistletoe infection on forest resources. Mistletoe management is a continuous process: new dwarf mistletoe infections take 3- to 5-years (latent period) to produce visible aerial shoots and not all infection can be detected and removed during one treatment. At least one treatment is recommended 5 to 10 years after an initial treatment, and can be accomplished during regularly scheduled silvicultural or prescribed fire treatments.

Several features of dwarf mistletoes make them ideal candidates for cultural management[xiii]:

- Dwarf mistletoes require a living host to survive. Mistletoe dies when an infected tree or branch is cut.
- Dwarf mistletoes are commonly restricted to a single host species or a group of closely related species. Non-host species can be favored during stand treatments.
- Dwarf mistletoes have fairly long life cycles and slow spread rates.
- Spread rates average only 1 foot per year. Although birds contribute to long-distance dispersal of seeds, this is rare and of little practical significance from a control perspective.
- Southwestern dwarf mistletoe-infected ponderosa pine trees are generally easy to detect due to the presence of yellow-orange shoots and witches' brooms. Trees in heavily infested stands show signs of short stature, decline, and mortality.

Managing dwarf mistletoe is difficult in stands under uneven-age management. Spread from overstory to understory trees, known as vertical spread, is rapid when seeds from infected overstory trees shower down onto younger trees. When newly infected trees in the understory begin to produce seed, lateral spread or tree-to-tree spread occurs among the young trees. Infection then progresses outward beyond the range of seeds produced from overstory trees. Researchers[xiv, xv] have measured the distance of infected seedlings from the source of overstory trees at different time intervals. In 20-year-old trees, nearly all infection is found within 35 feet of infected overstory trees. In 50-year-old trees, lateral spread of dwarf mistletoe increased the rate to nearly 80 feet in open stands and 65 feet in dense stands.

If uneven-aged treatments are to be applied in dwarf mistletoe infected stands, such as when implementing goshawk guidelines, it is best to select lightly infected stands on high quality sites. Although the presence of dwarf mistletoe in a stand is typically not related to site quality, the abundance and impacts of the pathogen on the growth and mortality of the host are strongly related to the quality of a site, soil type, and slope[xvi]. The incidence of southwestern dwarf mistletoe can be higher on dry sites with gentle slopes.

Researchers at the University of Montana in conjunction with the Bureau of Indian Affairs developed the following guidelines in managing ponderosa pine stands infected with southwestern dwarf mistletoe:

Condition	Recommended Treatment Options
Less than 15% of stems infected	Individual Tree Selection
15-25% stems infected	Group selection, less than 2 acres
Greater than 25% stems infected	Even-aged treatment

In certain stands with low-level, patchy distributions of dwarf mistletoe infection, group selection can be used to decrease disease incidence and impacts. However, residual trees located on the edges of openings need to be mistletoe-free in order to allow disease-free regeneration to develop in the newly created openings. Since latent infections are likely along the edges of a mistletoe center, it is recommended to cut 30-40 feet beyond the edge of visible infection. Limitations on size of openings, and reserve tree requirements can hinder the success of group selection treatments in dwarf mistletoe infected stands. Followup surveys and treatments need to be conducted 5-10 years after group removals in order to check the perimeter for infected trees.

Prescribed burns can also be used to reduce dwarf mistletoe infection levels. Heavily infected trees have been shown to have reduced post-burn survival rates compared to lightly infected or non-infected trees[xvii] [xviii]. Limbs located in the lower crowns of trees are killed during fire. Since dwarf mistletoe infections are generally more abundant in the lower crowns of infected trees, infection levels are decreased by the death of lower limbs.

Recommendations

Dwarf mistletoe infection levels are high in the McCracken project area. Since nearly 60% of forested stands with ponderosa pine are infected, dwarf mistletoe is expected to continue to influence the growth and development of stands overtime and methods to reduce the impacts of DM infection should be included in silvicultural prescriptions. Even-aged treatments are recommended in moderately to heavily dwarf mistletoe infected stands, while group selection can be used in lightly infected stands that are adequately stocked. Moderately infected sites can be thinned by targeting the removal of more severely infected trees while emphasizing the most vigorously growing trees. Severely infected stands should either receive a regeneration treatment, such as a shelterwood, or be deferred from treatment.

Treatments to mitigate DM impacts can be integrated with other treatment activities like reducing a stands susceptibility to fire or insect outbreaks. Uneven-aged treatments should only be considered in non-dwarf mistletoe infected or lightly infected stands on good quality sites that have well defined infection patches in which group selection can be used to target the removal of infected trees. The 4-acre patch cut size limitation set by the goshawk management guidelines is not an advisable treatment in stands that have greater than 25% infection rates, which includes many stands in the project area. In some of these stands, thinning, in which non-host trees and the less severely infected trees are retained on the site, can be the best option. The increase in space between trees helps limit spread and competition is reduced. This lessens infection levels

while still allowing trees to grow to maturity. In the most severely infected sites, deferral or selection of non-host species is recommended.

Regardless of the emphasis on even-aged or uneven-aged stands, proper selection and marking of leave trees is paramount to the success of treatment. In stands selected for group selection treatments it is important to attempt to remove trees with latent infections, as described above, cutting 30-40 feet beyond the edge of visible infection. In stands receiving individual tree selection treatments, leave trees should have none to very little mistletoe infection. Monitoring for followup treatments in 5 to 10 years is recommended.

Thinning slash may pose a short-term risk to residual trees in the thinning units or surrounding areas depending on the timing of thinning, local population of pine engraver beetles, and site and environmental factors such as site quality and precipitation. Our office recommends that slash be generated between late summer and the end of December, if possible, in order to lessen the buildup of ips bark beetles. Slash piles should be placed in stand openings as much as possible and the largest diameter slash put on the outside of the pile to promote quick drying. Tepee style slash piles are useful, with branches and small-diameter slash in the middle and the larger diameter material on the outside.

If you have any questions, please give me a call at (928) 556-2075.

/s/ Mary Lou Fairweather
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